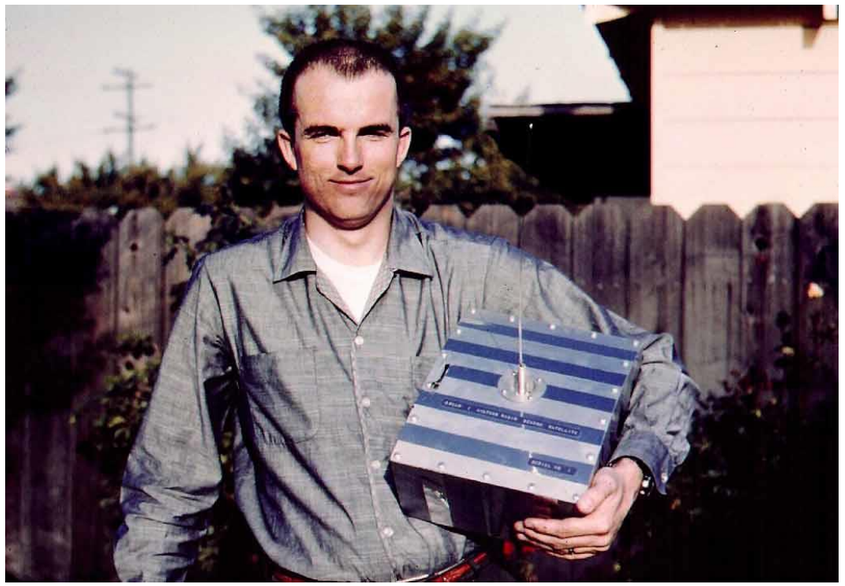
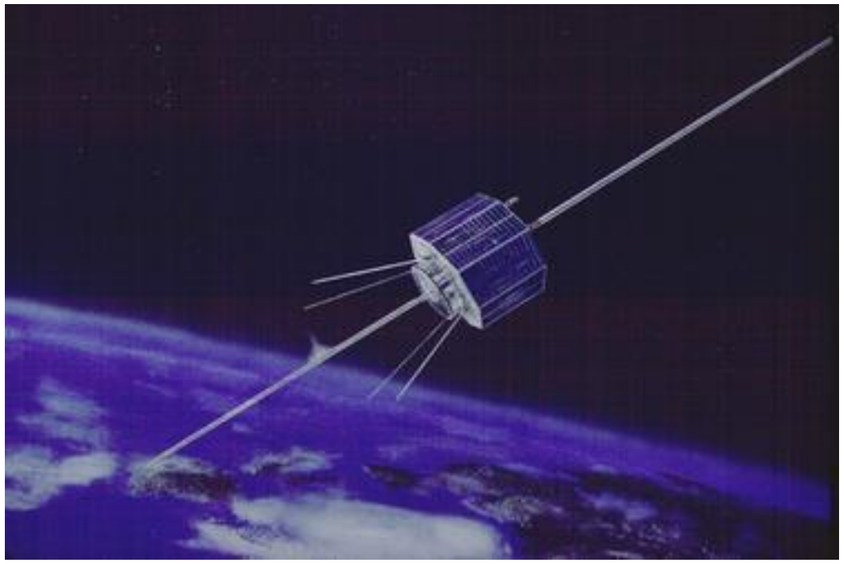
The Future of Amateur Radio Satellites in the CubeSat Era

The Radio Amateur Satellite Corporation (AMSAT) seeks to place an ongoing series of 3U or 6U satellites into highly elliptical orbits to provide long duration communications service to the worldwide amateur radio community. AMSAT's technical challenges in preparing a HEO satellite mission are very similar to what is required for Lunar or Interplanetary CubeSat missions, including harsh thermal and radiation environments, little or no magnetic field to torque against, and challenging communications links, which make this mission very different from the many LEO CubeSats that have been built and launched by other organizations.

AMSAT is seeking partnerships with other organizations to demonstrate new technologies in High Earth Orbit, to carry low cost scientific instruments into HEO and to qualify for NASA sponsored launches into Geosynchronous Transfer Orbit or other high altitude orbits whenever such an opportunity occurs.

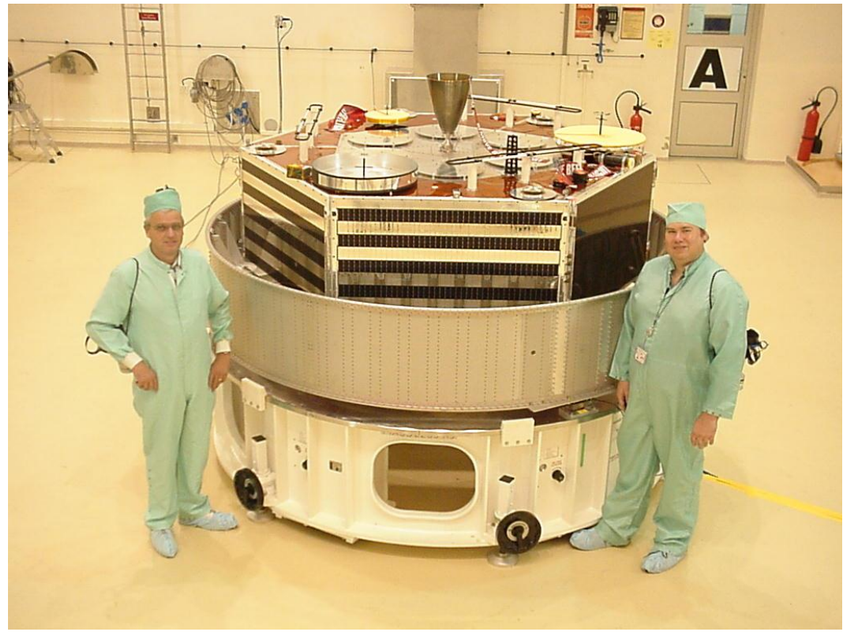
Radio Amateurs have been building and launching small satellites for over 50 years. OSCAR-1 was launched on December 12, 1961 as a secondary payload on the Thor-Agena rocket that launched the US Air Force Discoverer-36 mission. OSCAR-1 was the first satellite to be deployed as a secondary payload from a launch vehicle. The bureaucratic efforts required to secure permission to launch OSCAR-1 greatly exceeded the effort required to build the satellite and established a precedent for all subsequent secondary payload launches of the past five decades. OSCAR stands for “Orbiting Satellite Carrying Amateur Radio”. Today many agencies, laboratories, universities and high schools are building and launching dozens of small satellites every year, but it all started with OSCAR-1 in 1961.



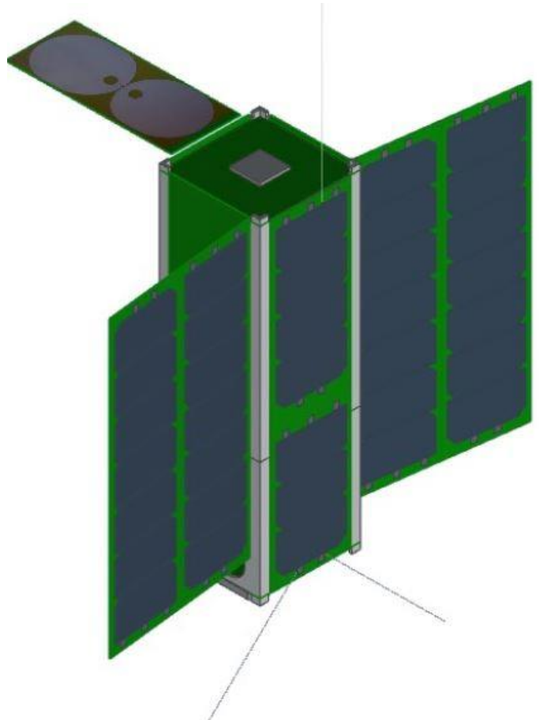


OSCAR-7 was launched by NASA on November 15, 1974. It was a joint effort of AMSAT groups in the United States, Canada, Germany and Australia. OSCAR-7 provided demonstrations of medical data relay from remote locations and Doppler location of ground transmitters for search and rescue operations. OSCAR-7 was fully operational for over six years until its battery short circuited in mid 1981. After more than two decades of silence, OSCAR-7's radio came back to life in 2002 when the main battery short cleared itself. After more than 40 years in space OSCAR-7's transponders continue to function when the solar panels are illuminated, supporting amateur radio communications on most overhead passes daily. It is believed to be the world's oldest functioning satellite.

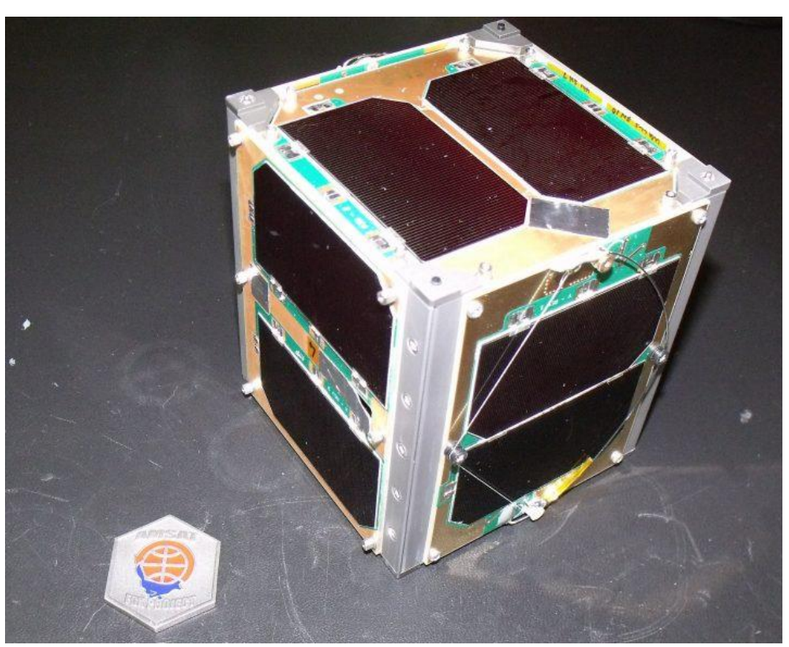
OSCAR-40 was an international project with components built by AMSAT organizations in more than a dozen countries. The 600 kilogram satellite carried a 400 Newton hypergolic bipropellant thruster, visible in the center of the satellite. AMSAT is the world's only organization to have flown a high performance hypergolic propulsion system on a small satellite. OSCAR-40 was launched by an Ariane 5 rocket on November 16, 2000. The satellite was placed in an elliptical orbit of 1000 km perigee by 58,000 km apogee. Its antennas cover all amateur satellite bands from 144 MHz to 24 GHz. The satellite also carried a GPS receiver provided by Goddard Space Flight Center which took some of the first measurements of the GPS signal above the GPS satellite constellation. The project's total development cost was about $3.5 million, funded by contributions from individual AMSAT members and organizations around the world.



The 21st century brought many new challenges to AMSAT. The popularity of small satellites made it more difficult for AMSAT to procure the low cost launch opportunities that it enjoyed in the past, and ITAR regulations placed severe restrictions on the international cooperation that made large satellite projects possible. In response to these challenges, AMSAT has built five 1U CubeSats in the “Fox” series carrying advanced communications transponders and scientific payloads, three of which have already been launched by the NASA CSLI program, with two more on the schedule.



Two AMSAT CubeSat proposals were recently accepted for NASA's Cubesat Launch Initiative. "GOLF-TEE" is a 3U Cubesat going to a 600 to 650 km near circular, 55 to 98 degree orbit with delivery in November 2019, and "GOLF-1" will be placed in a 1000 to 1400 km, 55 to 98 degree orbit with delivery in third quarter 2020. These satellites will demonstrate three axis attitude control and advanced communications technologies. We envision future satellites in this series reaching even higher altitudes where they can provide hours of communications service to radio amateurs around the world.



Why work with AMSAT? AMSAT can offer:

- A world-renowned volunteer engineering staff. We are amateurs in name only, many of our volunteers are well known in the aerospace and communications industries.

- A worldwide network of radio amateurs for tracking and telemetry acquisition, command uplink stations on three continents. AMSAT can handle all mission operations tasks.

- Citizen Science programs, educational and public outreach, lesson plans for teachers.

- Simplified licensing and IARU coordination. AMSAT has licensed more satellites under Part 97 than anybody else.

The Radio Amateur Satellite Corporation (AMSAT) is a non-profit, 501(c)(3) organization.
AMSAT-North America, 10605 Concord St, #304, Kensington, MD 20895-2526
http://www.amsat.org Phone: (301) 822-4376

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Low Earth Orbit missions offer very short pass durations and a limited number of users. Hams would like to have another high altitude satellite like AMSAT-OSCAR-10, AO-13, and AO-40. Ideally we could launch a new satellite every few years to replenish the constellation and encourage radio amateurs to invest in ground station antennas and equipment that will not become obsolete.

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AMSAT has built five 1U CubeSats in the “Fox” series, three of which have already been launched by the NASA CSLI program, with two more on the schedule. The Fox satellites carry a software defined transponder that can be reprogrammed in flight as well as experimental payloads from Vanderbilt University, Virginia Tech, Penn State Erie, and the University of Iowa.

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GOLF-TEE provides the opportunity for rapid deployment and on orbit testing of AMSAT’s Advanced Satellite Communications and Exploration of New Technology (ASCENT) program technology, including radiation tolerant transponder and Integrated Housekeeping Unit (IHU) technologies that will lead the way for low cost commercial off-the-shelf (COTS) systems that can function in the MEO and HEO radiation environments. GOLF-TEE will also provide for the development of “Five and Dime” Field-Programmable Gate Array Software Defined Radio (FPGA SDR) transponders for use on a variety of missions and orbits. Additionally, GOLF-TEE will carry a

Fox-1E design V/U linear transponder and the RadFx (Radiation Effects) experiment for Vanderbilt University.

AMSAT has partnered with Ragnarok Industries to provide communications systems for their Heimdallr 6U Lunar CubeSat, a finalist in NASA's CubeQuest Challenge. Heimdallr was not selected for a CubeQuest Challenge launch, but the technologies developed for that mission will be incorporated into AMSAT's GOLF program satellites.

Over the last five decades, AMSAT satellites have pioneered new space flight technologies including the first use of CMOS and plastic encapsulated integrated circuits in space, the first use of store and forward messaging, and flight validation of the Doppler location concept for the SARSAT/COSPAS emergency locator system. AMSAT contributed design expertise to the Canadian Space Agency's Microvariability and Oscillations of Stars (MOST) satellite. AMSAT-OSCAR-40 carried a Global Positioning System receiver sponsored by Goddard Space Flight Center that made the first published measurements of GPS signal strength above the orbit of the GPS satellite constellation. AMSAT's innovations have found their way into many government and commercial space missions.

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Point of Contact: Daniel Schultz, n8fgv@amsat.org, 301-879-8377

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